Harry Freeman

hfreeman@andrew.cmu.edu
harrynvfreeman.com

EDUCATION

Carnegie Mellon University, **School of Computer Science**, Pittsburgh, PA — Expected August 2023
Master of Science in Robotics

Cornell University, **College of Engineering**, Ithaca, NY — Awarded May 2017
Bachelor of Science in Electrical and Computer Engineering

PUBLICATIONS

Under Review

- **Autonomous Apple Fruitlet Sizing and Growth Rate Tracking with Computer Vision**
  Harry Freeman, Mohamad Qadri, Abhisesh Silwal, Paul O'Connor, Zachary Rubinstein, Daniel Cooley, George Kantor
  Submitted to IEEE Transactions on Robotics (T-RO)
  [Preprint][Video]

- **3D Reconstruction-Based Seed Counting for Sorghum Pannicles for Agricultural Inspection**
  Harry Freeman, Eric Schneider, Chung Hee Kim, Moonyoung Lee, George Kantor
  Submitted to IEEE International Conference on Robotics and Automation (ICRA), 2023
  [Preprint][Video]

Peer-Reviewed Conferences

- **3D Human Reconstruction in the Wild with Collaborative Aerial Cameras**
  Cherie Ho, Andrew Jong, **Harry Freeman**, Rohan Rao, Rogerio Bonatti, Sebastian Scherer
  International Conference of Intelligent Robots and Systems (IROS), 2021
  [PDF][Video]

Workshops

- **Towards Autonomous Apple Fruitlet Sizing with Next Best View Planning**
  Harry Freeman
  Accepted to AI for Agriculture and Food Systems (AAIFS), 2023
  [Preprint]

- **Toward Semantic Scene Understanding for Fine-Grained 3D Modeling of Plants**
  Mohamad Qadri, **Harry Freeman**, Franz Eric Schneider, George Kantor
  AI for Agriculture and Food Systems (AAIFS), 2022
  [PDF][Video]

RESEARCH EXPERIENCE

Agricultural Systems Lab - Carnegie Mellon University, Pittsburgh, PA — August 2021 – Present

- Successfully created a method to construct high-quality 3D models of sorghum panicles. Used seeds as semantic landmarks in 2D and 3D to improve reconstruction. Developed a density-based clustering approach that extends 2D gaussian smoothing into 3D and finds local maxima in a point cloud. Results demonstrate improved 3D reconstruction and more accurate seed counts compared to state-of-the-art methods.
- Built a real-time ROS-based computer vision application to size apple fruitlets in the field. Approach utilizes RAFT-Stereo, Mask-RCNN, Pix2Pix, and ellipse-fitting via a constrained least squares formulation.
- Successfully utilized Attentional Graph Neural Networks for cross-day fruitlet association in order to fully automate fruitlet tracking and abscise prediction. Achieved F1 score of 0.95 and abscise prediction within 3% of ground-truth.

- Currently working on next-best-view planning for fruitlet sizing. Implemented a method that uses coarse and fine occupancy maps to estimate information gain for viewpoint candidates. Now investigating reinforcement learning-based approaches.

AirLab - Carnegie Mellon University, Pittsburgh, PA August 2020 – July 2021

- Assisted PhD student Cherie Ho on multi-drone collaboration for 3D human reconstruction.
- Worked on multi-robot visual tracking, utilizing Kalman filters to fuse raycasted position estimates from multiple robots tracking the same target.
- Was primary contributor to the 3D reconstruction post-processing pipeline. Investigated the performance of deep pose estimation networks and multi-view reconstruction algorithms on real and simulated data.
- Modified AirSim and Unreal Engine source code to extract simulated ground-truth skeletal mesh and bone positions of actor.
- Integrated and tested OpenVINO with ROS for real-time person detection to run on Intel NUC.

Technology for Avian Birds and Environmental Research - Cornell University, Ithaca, NY August 2016 – May 2017

- Assisted professor in researching, configuring, and programming small, low-powered, transponding tags to be used to study the migration patterns of birds using Si1060 microcontroller.
- Investigated the performance of different data modulation schemes, including FSK, ASK, and QAM, and evaluated their performance with regard to power, signal integrity, and data loss.
- Improved average power consumption by enabling low-power mode configuration on the microcontroller.
- Results of work deployed to study flight patterns of barn swallows migrating from California to Argentina.

RELEVANT MASTER'S COURSEWORK

Deep Learning for Robotics	Learning for 3D Vision	Computer Vision
Statistical Techniques in Robotics	Learning-based Image Synthesis	Math Fundamentals for Robotics

RELEVANT ONLINE COURSEWORK

Reinforcement Learning (U)	Artificial Intelligence for Robotics (U)	Deep Learning Specialization (C)

U – courses taken through Udacity C – courses taken through Coursera

WORK EXPERIENCE

Amazon AWS AI Devices, Palo Alto, CA August 2020 – August 2021

Senior Software Development Engineer

- Senior embedded software engineer for AWS Panorama – a machine learning appliance that allows IP cameras to run computer vision and deep learning applications at the edge.
- Developed multi-threaded and multi-process application level software that ran on the device. Supported the full application lifecycle from OTA to deployment to inference which allowed customers to run custom applications.
- Led the design and development of the entitlement and encryption service, a service which utilizes MQTT to communicate with the cloud and securely manages the IP of 1P and 3P applications.
- Contributed to the development of the data source service, which allowed customers to stream data from RTSP cameras and video files in real time.

Eversight, Palo Alto, CA July 2019 – August 2020

Software Engineer

- Worked to build large scale reinforcement learning networks to optimize prices in consumer-goods retail stores.
- Improved price recommendation system speed by 80% by re-designing backend container-driven system architecture using Kubernetes and Google Cloud Platform. The system could effectively scale and process resource heavy tasks, including processing millions of transaction records daily and optimizing in-store prices using customer data.
- Led the architecture design that loaded customer data into our system using a scalable event driven architecture and Apache Beam, reducing the time of the overall process by 50%.

Edelman Financial Engines, Sunnyvale, CA April 2018 – July 2019
Senior Software Engineer

- Developed an online financial planning tool to provide a new medium for financial advisors to offer financial advice.
- Led the design of a microservice that automated the process of migrating customer data from a competitor's service to our platform.
- Led the design of a report generation service to aggregate customer information and present likelihood of retirement goal success.
- Integrated financial algorithms that utilized Monte Carlo Simulations and additional features into the product in order to allow the user to visualize and modify their estimated portfolio performance.

Macdonald, Dettwiler, and Associates, Vancouver, BC August 2017 – March 2018
Embedded Software Engineer

- Acted as part of a small research and development team whose goal was to determine the feasibility and performance of implementing SAR image processing algorithms on FPGAs for real-time sea vessel detection and classification.
- Improved classification and detection speed by three orders of magnitude by successfully constructing embedded RTL designs in C and VHDL to implement SAR signal processing algorithms.
- Evaluated performance of system with regard to memory, time, and quantization constraints.

PROJECTS

Graduate

- *In Progress:* Applying deep reinforcement learning techniques to learn a unified policy to control a quadruped mounted with a mobile arm with the task of tracking a moving target. The hypothesis is that this configuration will enable the robot to explore more complex terrains when compared to using a fixed egocentric camera. Agent is trained using PPO and advantage mixing in Isaac Gym simulation environment to utilize parallelized processing.
- *In Progress:* Applying deep reinforcement learning techniques towards informative path planning for drone mapping. Agent is learning an optimal policy to intelligently explore an unknown map to visit areas of high interest. Experimenting with both on-policy and off-policy approaches in addition to model-based and model-free algorithms.
- Utilized NeuS to create accurate, watertight meshes of plants from sparse 2D images. Models were made generalizable by incorporate Reptil meta-learning into training. Results demonstrate the meta-learning improves reconstructions with fewer training iterations, and are approach is able to generate realistic meshes and novel view synthesis with sparser 2D images compared to naïve approaches.
  [Project Writeup] [Data Repo] [Code Repo]
- Utilized Generative-Adversarial Networks for coarse style and scene data augmentation. Method was based off Swapping AutoEncoders. Results successfully demonstrated that swapping latent style codes is effective approach for data augmentation to allow models to better generalize and not overfit the training data.
  [Project Webpage] [Code Repo]

Undergraduate

- Built an iOS controlled massage vest that allowed the user to create a custom massage by controlling the pattern, region, and intensity over Bluetooth. Designed both the hardware-control system and multi-threaded software. Published article in *Circuit Cella.r* Issue 330. Massage Vest Uses PIC32 – Controlled with an iOS App.
  [Project Webpage]
- Built a competition-winning Arduino-based autonomous robot that could self-navigate and map a maze to be displayed on a remote video-base station. Achieved the lowest average navigation time with no obstacle collision.

Personal

- Built a real-time face detection system in Cython and C using a variation of Histogram of Oriented Gradients. SVM was trained using LFW dataset, and overlapping bounding boxes are reduced using non-maximum suppression.
  [Project Webpage] [GitHub Repo]
- Built scale and rotation invariant keypoint descriptor in Matlab based of Lowe's SIFT algorithm. Dictionary was built using Home Objects Dataset.
  [GitHub Repo]

- Built a voice-recorder using PIC32 that could record and play back audio with adjustable sampling rate. Utilized internal ADC, DMA, PWM and flash storage with external microphone and amplifier.
  [GitHub Repo]
- Built a quaternion and complementary-filter based system to accurately track orientation of an MPU9255 IMU which was used to control a mouse. Orientation was implemented from scratch without use of a Digital Motion Processor.
  [GitHub Repo]
- Designed a system to control television over Bluetooth from phone using ATMega2560 microcontroller.
  [GitHub Repo]
- Built a multi-radio network using NRF24 transceivers to track and analyze squash/tennis movement patterns that can be controlled via Bluetooth from iOS.
  [GitHub Repo]

SKILLS

Programming Languages	C++, C, Python, Java, Matlab, VHDL, SQL
Robotics	ROS, Gazebo, MoveIt, AirSim
Software	Docker, Isaac Gym, PyTorch, GCP, AWS, Kubernetes
Hardware	Oscilloscope, Spectrum Analyzer, Logic Analyzer, Microcontrollers

OTHER ACTIVITIES

Cornell Varisty Squash Team August 2013 – May 2017

- Competed on the Cornell Varsity Squash Team. Trained, travelled, and competed six days a week.
- Captained the team my Senior year. Led and managed the team alongside the coach.
- Played at the number one position Junior and Senior years.
- CSA Scholar Athlete Junior and Senior years.
- Three-time recipient of team sportsmanship award.
- Two-time recipient of team most improved award.

Matlab Consultant August 2014 – December 2014

- Acted as a consultant for the Introduction to Matlab course.
- Ran labs and discussions. Worked through exercises with students and provided supplemental information.
- Held office hours to answer student questions regarding material, exam preparation, and lab assignments.
- Graded assignments and exams.